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PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

WOLFF, BREGMAN AND GOLLER
P.O. Box 1352
91013 Jerusalem
ISRAËL

Date of mailing (day/month/year)
25 April 2001 (25.04.01)

Applicant's or agent's file reference
131,652 PCT

IMPORTANT NOTIFICATION

International application No.
PCT/IL00/00513

International filing date (day/month/year)
29 August 2000 (29.08.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address
SATEC ECOCHEM LTD.
Har Hachotzvim Science Based
Industrial Park
P.O. Box 45022
91450 Jerusalem
Israel

State of Nationality: IL
State of Residence: IL
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [ ] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address
JOMA CHEMICAL AS
7898 Limingen
Norway

State of Nationality: NO
State of Residence: NO
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:
Please forward powers of attorney to the International Bureau.

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[X] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
Jean-Marie McAdams
Telephone No.: (41-22) 338.83.38

09/630,820

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
131,652 PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/IL 00/00513	29/08/2000	30/08/1999
Applicant		
SATEC ECOCHEM LTD. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   SULFATISATION PROCESS FOR METAL EXTRACTION FROM SULFIDE ORES

5. With regard to the **abstract,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [ ] as suggested by the applicant.

   [X] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL 00/00513

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

The invention provides a hydrometallurgical process for treating metal-containing sulfide ores and concentrates, comprising reacting said metal-containing sulfide with concentrated sulfuric acid at a temperature of between about 300°C and 400°C in the presence of oxygen to produce a solid metal sulfate product and a gaseous product which is primarily SO3, wherein said metal is selected from the group consisting of iron, copper, zinc, nickel, cobalt and manganese. Said metal sufate product is then leached with dilute sulfuric acid to form a metal-containing solution, from which the metal values are separated by precipitation at raised H2SO4-concentrations obtained by saturating the solution with the gaseous SO3 from the sulfatization reaction step.

Wolff, Bregman and Goller

PATENT AND TRADE MARKS ATTORNEYS

Zwi Bregman, Dipl. (Elec.), B.Sc. (Phys.)
Gilbert Goller, B.A. (Chem.), Jur. Doc.
Yosef Bregman, LL.B., Adv.
Yacov Goller, B.A. (Biochem.)

STREET ADDRESS: 19 B KEREN HAYESOD STR., JERUSALEM 94188, ISRAEL
MAILING ADDRESS: P.O.Box 1352, JERUSALEM 91013, ISRAEL

TEL. 972-2-6242255
FAX. 972-2-6242266

April 9, 2001

INTERNATIONAL BUREAU OF WIPO
34, chemin des Colombettes
1211 Geneva 20
SWITZERLAND

VIA FACSIMILE
49-89-239-94465
AND VIA COURIER

Re: International Patent Appln. No. PCT/IL00/00513
in the name of JOMA CHEMICAL AS
Our Ref: 131,652 PCT

Dear Sirs:

Transmitted herewith please find one copy of an amended claim pages 9 and 10 to replace original pages 9 and 10 of the specification filed.

Following receipt of the International Search Report, the Applicant wishes to amend the claims under PCT Article 19 and we are accordingly filing with the confirmation copy of this letter being sent by courier, three copies of an amended sheets 9 and 10 to replace sheets 9 and 10 of the specification as filed.

Claims 1, 3, 4 and 6 have been replaced by amended claim 1, wherein claim 1, line 1 has been amended to clarify that the metal containing sulfide ores and concentrates are "treated" and line 2 has been amended to clarify that it is said metal containing sulfide ores and concentrates, i.e., the metal containing sulphidic materials which are reacted, claim 3 has been amended to indicate, as seen in the examples that the preferred embodiment is a stage-wise process and to clarify the precipitation of metallic sulphates from the solution, the dependency of claim 4 has been corrected and the language of claim 6 rendered more precise.

Very truly yours,
WOLFF, BREGMAN AND GOLLER

G. Goller

Gilbert Goller, Patent Attorney
Agent for Applicant

gg/mk/09-09

WHAT IS CLAIMED IS:

1. A hydrometallurgical process for producing metal-containing sulfide ores and concentrates, comprising reacting said metal-containing sulfide with concentrated sulfuric acid at a temperature of between about 300°C and 400°C in the presence of oxygen to produce a solid metal sulfate product and a gaseous product which is primarily SO_3, wherein said metal is selected from the group consisting of iron, copper, zinc, nickel, cobalt and manganese.
2. A process according to claim 1, wherein said metal sulfate product is then leached with a dilute solution of sulfuric acid, having a concentration of between 5% and 35% to extract metal values therefrom and to form a metal-containing solution.
3. A process according to claim 2, wherein said SO_3 gaseous product formed from said reaction is subsequently combined with said metal-containing solution to raise the concentration of sulfuric acid in said solution to about 35% to 50% and to effect the precipitation of metal from said solution.
4. A process according to claim 4, wherein the amount of sulfuric acid upon mixing with one weight portion of sulfide ore is ≥0.94 weight portions of 98% sulfuric acid.
5. A process according to claim 1, wherein the sulfatization process is carried out at a temperature of between 330°C and 350°C.
6. A process according to claim 1, wherein the sulfatization process is carried out at constant oxidation with oxygen from air, its amount being ≥150% of the stoichiometrically required amount.
7. A process according to claim 1, wherein leaching of the sulfatized product is carried out in solution of sulfuric acid, having a concentration of about 15% to 25%.
8. A process according to claim 3, wherein separation of metal sulfate from the solution was made by its precipitation in sulfuric acid solutions of 40%-45% H_2SO_4.
9. A process according to claim 8, wherein a high concentration of sulfuric acid is achieved by saturation of the solution with gas SO_3 at room temperature.

10. A process according to claim 9, wherein purification of sulfuric acid from the admixtures aimed at production of the acid ready for sale was performed by saturation with gas SO_3 up to a concentration of sulfuric acid of 98.3%.

11. A process according to claim 1, wherein said metal is iron.

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(71) Applicant *(for all designated States except US)*: **SATEC ECOCHEM LTD.** [IL/IL]; Har Hachotzvim Science Based Industrial Park, P.O. Box 45022, 91450 Jerusalem (IL).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **FLAX, Solomon** [IL/IL]; Rechov Neva Yaacov 102/5, 98350 Jerusalem (IL).

(74) Agent: **WOLFF, BREGMAN AND GOLLER**; P.O. Box 1352, 91013 Jerusalem (IL).

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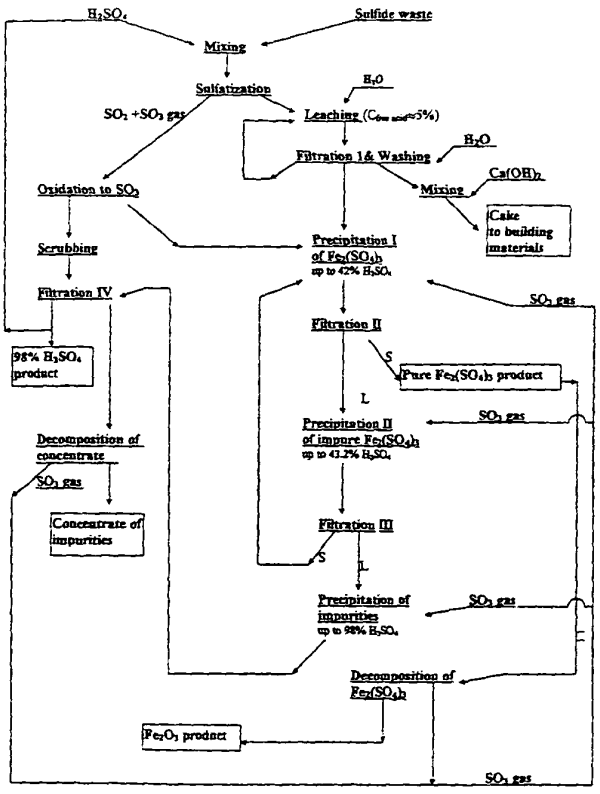
[Continued on next page]

(54) Title: SULFATISATION PROCESS FOR METAL EXTRACTION FROM SULFIDE ORES



(57) Abstract: The invention provides a hydrometallurgical process for treating metal-containing sulfide ores and concentrates, comprising reacting said metal-containing sulfide with concentrated sulfuric acid at a temperature of between about 300 °C and 400 °C in the presence of oxygen to produce a solid metal sulfate product and a gaseous product which is primarily SO_3, wherein said metal is selected from the group consisting of iron, copper, zinc, nickel, cobalt and manganese. Said metal sulfate product is then leached with dilute sulfuric acid to form a metal-containing solution, from which the metal values are separated by precipitation at raised H_2SO_4-concentrations obtained by saturating the solution with the gaseous SO_3 from the sulfatization reaction step.

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patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

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— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SULFATISATION PROCESS FOR METAL EXTRACTION FROM SULFIDE ORES

Technical Field

The present invention relates to the field of hydrometallurgical processing of sulfide metal-containing ores and sulfide waste (dump sulfide tails) obtained after separation of sulfide concentrates of zinc, copper etc. by flotation aimed at production of metal sulfates, oxides, and other compounds as well as sulfuric acid, wherein said metal is selected from the group consisting of iron, copper, zinc, nickel, cobalt and manganese.

Background Art

The method for calcination of iron sulfides, pyrite, marcasite etc. at a high temperature ≥ 900°C according to the reaction:

$$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2 \quad (1)$$

is known. The escaping gas is converted to sulfuric acid, and a calcine (Fe_2O_3) is used for production of various iron compounds or applied in ferrous metallurgy to obtain metal iron. However, because of a high residual content of sulfur in the calcine, its application in metallurgy is limited and it is usually dumped. [Short Chemical Encyclopedia, Moscow, 1979].

There is known a method of sulfatization of sulfide materials by their treatment with concentrated sulfuric acid at 200°C - 300°C [Pat US 1895811, 1933; L.E.Makovezky, H.Morgan]. This process is described by a reaction:

$$MeS + 4H_2SO_4 \rightarrow MeSO_4 + 4\,SO_2 + 4H_2O \quad (2)$$

where Me - Fe, Ni, Zn, Cu etc.

However, the largest extent of sulfatization (78.4%) of pyrite (FeS_2) was achieved at 200°C, the sulfatization extent of copper sulfides was lower.

With temperature increase to 300°C the reaction of pyrite sulfatization proceeds as follows:

$$FeS_2 + H_2SO_4 \rightarrow FeSO_4 + S^0 + H_2S \quad (3)$$

At a temperature 300°C sulfuric acid behaves as a strong oxidizer and a portion of iron is oxidized to Fe(III) [S.S.Naboichenko, V.I.Smirnov "Hydrometallurgy of copper", Moscow, "Metallurgiay", 1974]:

$$2FeS_2 + 3\,H_2SO_4 \rightarrow Fe_2(SO_4)_3 + S^0 + 3H_2S \quad (4)$$

There exists a method for sulfatization of zinc and copper sulfides by their dissolving in sulfuric acid of a high concentration (45 - 70%) at a temperature below the boiling point of these solutions (for 45% H_2SO_4 - ≤130°C; for 70% H_2SO_4 - ≤140°C). Under these conditions zinc sulfate was obtained ($ZnSO_4$ H_2O), sulfatization of copper and iron sulfates proceeded incompletely [Pat. US 5711922, Jan.27.1998; O'Brien, Robert N.].

Sulfide ores and concentrates can be also treated with a mixture of sulfuric and nitric acids at 110 - 170°C. Sulfuric acid concentration is 40 - 65%. The amount of nitric acid required for sulfatization is 0.5 - 3.0 moles of HNO_3 per 1 mole of sulfides which are contained in the treated material [Pat. US 5484579, Jan.16, 1996; O'Brien, Robert N.]. This technology does not provide a complete sulfatization of metal sulfides as well. In addition a complicated problem of utilization of gases SO_2 and SO_3, which contain nitrogen oxides arises.

All the patents mentioned above deal with a complicated and yet unsolved problem of separation of admixtures of sulfates of such metals as Al, Cu, Zn, Ni etc. from iron sulfates.

Usually the solution of metal sulfates obtained after sulfatization and leaching is oxidized with oxygen of air or by other methods in order to convert Fe^{2+} to Fe^{3+}, then the solution is adjusted to pH=2, iron precipitates as $Fe(OH)_3$, and the admixtures remain in solution. To obtain iron (III) sulfate, iron hydroxide is again dissolved in sulfuric acid. Extraction of admixtures from the sulfuric acid solution is a complicated problem.

If the solution obtained after sulfatization contains a large amount of copper, the method of cementation with iron scrap is applied. It is described by the following reactions:

$$Fe^0 + Cu^{2+} \rightarrow Cu + Fe^{2+} \qquad (5)$$

$$2Fe^{3+} + Fe \rightarrow 3Fe^{2+} \qquad (6)$$

Copper precipitates as a metal powder, and iron converts to its bivalent form $FeSO_4$, all admixtures, except for copper, are in solution with iron. Isolation of pure iron sulfate from this solution is a large technological problem.

The present invention is aimed at the development of the method for processing sulfide ores and concentrates, in particular pyrite, performed at lower temperatures than pyrite calcination and which results in the production of highly

pure iron sulfates without using additional amounts of reagents for neutralization of strongly acidic solutions.

Disclosure of the Invention.

Thus, according to the present invention, there is now provided a hydrometallurgical process for producing metal-containing sulfide ores and concentrates, comprising reacting said metal-containing sulfide with concentrated sulfuric acid at a temperature of between about 300°C and 400°C in the presence of oxygen to produce a solid metal sulfate product and a gaseous product which is primarily SO_3, wherein said metal is selected from the group consisting of iron, copper, zinc, nickel, cobalt and manganese.

In preferred embodiments of the present invention said metal is iron.

In preferred embodiments of the present invention said metal sulfate product is then leached with a dilute solution of sulfuric acid, having a concentration of between 5% and 35% to extract iron values therefrom and to form an iron-containing solution.

In especially preferred embodiments of the present invention said SO_3 gaseous product formed from said reaction is subsequently combined with said metal-containing solution to raise the concentration of sulfuric acid in said solution to about 35% to 50% and to effect the precipitation of said metal from said solution.

Thus, in a most preferred embodiment of the present invention the milled sulfide ore, particularly pyrite FeS_2, is mixed with concentrated (98.3%) sulfuric acid and calcined in a furnace at a temperature about 338.8°C and at a constant blowing of air or air enriched with oxygen.

A temperature 338.8°C is the maximum temperature for sulfuric acid solutions, this is the boiling temperature of azeotrope containing 98.3% of H_2SO_4. With a temperature rise pyrite and other sulfides much better interact with sulfuric acid. In addition, an application of oxygen of air results in the following reaction for this process:

$$4FeS_2 + 6H_2SO_4 + 15O_2 \rightarrow 2Fe_2(SO_4)_3 + 8SO_3 + 6H_2O \qquad (7)$$

The product resulted from sulfatization was leached in diluted solution of sulfuric acid (≤36% at ≈90 - 100°C). The extraction of iron to solution was 95%, of them 92.15% was in a form of Fe(III).

After leaching the unsolved cake, containing SiO_2, $CaSO_4$, aluminosilicates etc, was separated from the solution by filtration. Then gas SO_3, formed in the sulfatization process, was blown through the solution so that to increase the concentration of sulfuric acid to 42% (Precipitation I)

$$SO_3 + H_2O \rightarrow H_2SO_4 \quad (8)$$

At such a concentration of sulfuric acid 89.1% of iron was salted out (precipitated) as highly pure $Fe_2(SO_4)_3 \cdot 4H_2SO_4$. This product was filtered off, and gas SO_3 was continuosly blown through the solution to a concentration of sulfuric acid 43.0 - 43.2% H_2SO_4. During this process rather unpure crystals of $Fe_2(SO_4)_3$ precipitated (Precipitation II), which were returned to stage Precipitation I for further purification. Solutions after Precipitation II were saturated with SO_3 to H_2SO_4 concentration 98.3%. At such a concentration of sulfuric acid practically all the admixtures precipitated (Precipitation III), filtered off and used for production of a concentrate of nonferrous metals. The sulfuric acid composition corresponded to that of sulfuric acid produced for sale. The acid was partially returned to the head of the process for sulfatization, partially it was used as a product ready for sale.

Iron sulfate crystals obtained after Precipitation I were decomposed at ≈700°C

$$Fe_2(SO_4)_3\ 4H_2SO_4 \rightarrow Fe_2O_3 + 3SO_3 + 4H_2SO_4 \quad (9)$$

Gas SO_3 formed in this process is used at one of the precipitation stages. The admixtures after precipitation III are sulfates of such metals as Al, Ti, Zn and others. After filtration they were decomposed at 600°C -700°C:

$$Me_x(SO_4)_y \rightarrow xMeO + ySO_3 \quad (10)$$

The escaping gas SO_3 was also used for precipitation, and the residual formed after calcination is a concentrate of nonferrous metal oxides. The composition of this concentrate depends on the composition of a raw material used.

The invention will now be described in connection with certain preferred embodiments with reference to the attached flow sheet and the following examples so that it may be more fully understood.

With specific reference now to the examples, it is stressed that the particulars discussed are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood

description of the principles and conceptual aspects of the invention. It is not intended, however, to limit the invention to these particular embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the scope of the invention as defined by the appended claims. Thus, the following examples which include preferred embodiments will serve to illustrate the practice of this invention, it being understood that the particulars shown are by way of example and for purposes of illustrative discussion of preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of formulation procedures as well as of the principles and conceptual aspects of the invention.

Description of Preferred Embodiments

Example 1.

Sulfide waste, which was obtained from sulfide ore after separation of zinc and copper concentrates by flotation, is used as a raw material. Sulfide waste has the following composition: Fe - 34.0%; Al -3.34%; Ca 3.37%; Mg -3.08%; Ti -0.72%; Zn - 0.21%; Pb -0.03%; Cu - 0.15%; Mn - 0.07%; Ni - 0.003%; Co - 0.015%; V - 0.02%; Na - 0.023%; K - 0.14%; As - 0.04%; Ag - 3.2 10^{-4}%; S - 22.6%; Si - 4.97%; H_2O - 9.1%, and the following fraction analysis:

Particle size, micron	Fraction content, %
+350	0.90
+210	4.82
+99	16.07
+75	14.63
+44	34.13
-44	29.45
	In total 100%

A sample of sulfide waste was milled in a ball mill to a size -75 micron -100%, then it was mixed at room temperature with concentrated sulfuric acid in a ratio 1:0.94 by weight. Mixing was made during 30 min., then the mixture obtained was loaded to a tube furnace, where the sulfatization process occurred at 338°C. Air was blown during the sulfatization process. The amount of air required was 1900 l/1 kg of sulfide waste, that is 200% of the amount theoretically required according to

reaction (7). Sulfatization time is 2 hours. Gas SO_3 escaping at sulfatization is forwarded to scrubbers for precipitations I, II or III. The product resulted from sulfatization was loaded to a reactor for leaching (2.4 litters of 20% H_2SO_4 per 1 kg of the sulfatized product). Leaching was performed at a temperature 90 - 100°C for 2 hours at constant stirring, the pulp was filtered on a vacuum filter, the solution goes in a scrubber for precipitation of pure iron (III) sulfate (Precipitation I), and the cake is washed with water on a filter. Sulfuric acid was added to wash water to a concentration ≈20% and used for leaching of the following portion of the sulfatization product.

The cake after washing contained 0.1% H_2SO_4 free; 11.5% $CaSO_4$; 10.65% SiO_2; Al_2O_3; TiO_2 and other admixtures. It was neutralized by slaked lime [$Ca(OH)_2$] that resulted in an increase in $CaSO_4$ content to 33-34%. This product can be used as a building material.

After leaching the solution contained 95.8g/l Fe (342.8 g/l $Fe_2(SO_4)_3$), it was used for Precipitation I. The crystals obtained after Precipitation II were returned to this solution.

Precipitation I was made at room temperature by blowing SO_3 (gas) in order to increase the sulfuric acid concentration in solution to 42%. At such a concentration of sulfuric acid ≥89.1% Fe precipitated in a form of chemically pure complex salt $Fe_2(SO_4)_3 \cdot 4H_2SO_4$; ≥99.7% of admixtures remained in solution.

Iron sulfate $Fe_2(SO_4)_3 \cdot 4H_2SO_4$ was filtered on a vacuum filter, filtrate was used in the Precipitation II stage, and the salt was decomposed at a temperature 600-700°C for 1 hour. The formed gas SO_3 and sulfuric acid vapor were applied to precipitate iron salts, admixtures, and to produce sulfuric acid for sale in accordance with the given technological scheme. The product obtained after calcination contained ≥99.7% of Fe_2O_3, by its physical and chemical properties it was iron-oxide pigment of high quality. This product can be used both for the production of the high quality iron powder and various iron compounds (Fe_3O_4 etc.). The filtrate after Precipitation I contained 42% H_2SO_4; 21.6 g/l Fe. At stage Precipitation II it was saturated with SO_3 gas to a concentration of sulfuric acid in solution equal to 43.2%, the iron content in solution decreased to 7.7g/l. A portion of admixtures, about 2% of the total amount in the raw material, was precipitated together with iron (III) sulfate

crystals. The crystals were filtered and then used in Precipitation I, and the solution containing admixtures was forwarded to precipitation III.

Precipitation III was also performed with $SO_3$3recipitation III was also performed with SOOolution equal to 43.2%, the iron content in solution decreased to 7.7g/l. A portion of admixtures, about 2% of the total amount in the raw material, was precip33recipita$_3$3recipitation III was also performed with SOOolution equal to 43.2%, the iron content in solution decreased to 7.7g/l. A portion of admixtures, about 2% of the total amount in the raw material, was precipitated together with iron (III) sulfate crystals. $_3$3$_3$3recipitatio$_3$3$_3$3recipitation III was a$_3$3recipitation III was also perf$_3$3rec$_3$3recipitation III was also performed with SOOolution equal to 43.2%, the iron content in solution decreased to 7.7g/l. A portion of admixtures, about 2% of the total amount

Comparative Example 2.

Under conditions of example 1, one weight portion of sulfide waste was mixed with 0.72 weight portions of 98.3% H_2SO_4, that was 80% of the theoretically required amount of sulfuric acid. After sulfatization about 70% of iron yielded to solution.

Example 3.

Under conditions of example 1, one weight portion of sulfide waste was mixed with 1.1 weight portions of 98.3% H_2SO_4 (120% of the theoretically required amount). The iron yield to solution was 95%.

Comparative Example 4.

Under conditions of example 1, sulfatization was performed at a temperature 250°C. The yield of iron in solution was 66%.

Example 5.

Under conditions of example 1, sulfatization was performed at a temperature 350°C. The yield of iron in solution was 95%.

Example 6.

Under conditions of example 1, the sulfatization was performed at the air amount equal to 100% of the stoichiometric amount. Elementary sulfur and SO_2 were formed, about 30% of iron was in its bivalent form.

Comparativ Example 7.

Under conditions of example 1, leaching of the sulfatization product was made in 2% sulfuric acid solution (20g/l H_2SO_4). The yield of iron to solution was 70%.

Example 8.

Under conditions of example 1 leaching was made in solution of 5% sulfuric acid. The yield of iron to solution was 94.5%.

Example 9.

Under conditions of example 1, leaching was made in 35% sulfuric acid solution. The yield of iron to solution was 94.8% because of the partial precipitation of iron sulfate.

Comparative Example 10.

Under conditions of example 1, precipitation of iron sulfate was performed by saturation of the solution with SO_3 gas up to H_2SO_4 concentration equal to 40%. Iron yield in pure crystals was 75%.

Example 11.

Under conditions of example 1 precipitation of iron sulfate was made by saturation of the solution with gas SO_3 up to a sulfuric acid concentration 45%. Iron yield in crystals increased to 93%, however, Fe_2O_3 obtained from these crystals and contained 98% of Fe_2O_3 and 2% of oxides of other metals.

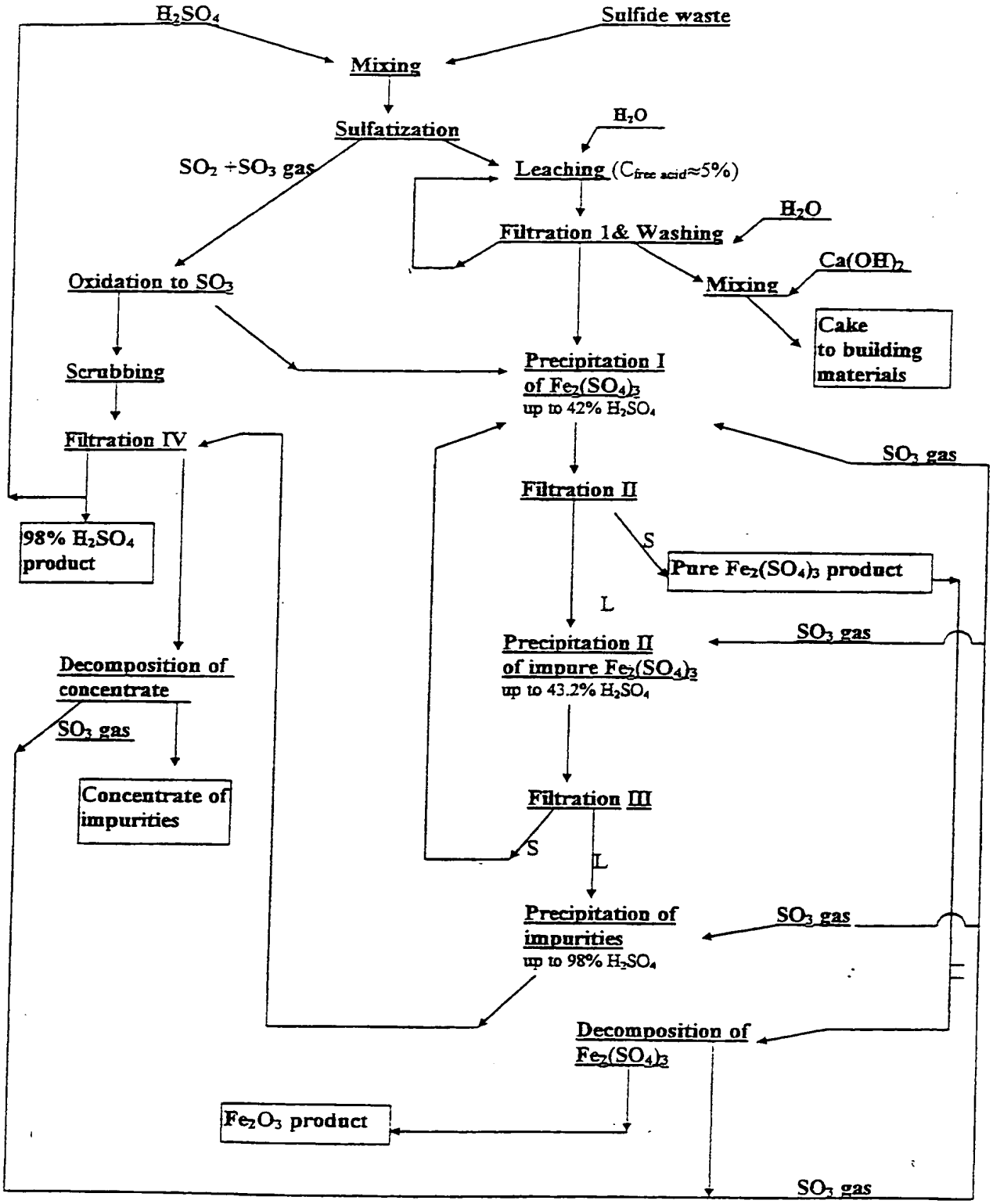
It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative examples and that the present invention may be embodied in other specific forms without departing from the essential attributes thereof, and it is therefore desired that the present embodiments and examples be considered in all respects as illustrative and not restrictive, reference being made to the appended claims, rather than to the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT IS CLAIMED IS:

1. A hydrometallurgical process for producing metal-containing sulfide ores and concentrates, comprising reacting said metal-containing sulfide with concentrated sulfuric acid at a temperature of between about 300°C and 400°C in the presence of oxygen to produce a solid metal sulfate product and a gaseous product which is primarily SO_3, wherein said metal is selected from the group consisting of iron, copper, zinc, nickel, cobalt and manganese.
2. A process according to claim 1, wherein said metal sulfate product is then leached with a dilute solution of sulfuric acid, having a concentration of between 5% and 35% to extract metal values therefrom and to form a metal-containing solution.
3. A process according to claim 2, wherein said SO_3 gaseous product formed from said reaction is subsequently combined with said metal-containing solution to raise the concentration of sulfuric acid in said solution to about 35% to 50% and to effect the precipitation of metal from said solution.
4. A process according to claim 4, wherein the amount of sulfuric acid upon mixing with one weight portion of sulfide ore is ≥0.94 weight portions of 98% sulfuric acid.
5. A process according to claim 1, wherein the sulfatization process is carried out at a temperature of between 330°C and 350°C.
6. A process according to claim 1, wherein the sulfatization process is carried out at constant oxidation with oxygen from air, its amount being ≥150% of the stoichiometrically required amount.
7. . A process according to claim 1, wherein leaching of the sulfatized product is carried out in solution of sulfuric acid, having a concentration of about 15% to 25%.
8. A process according to claim 3, wherein separation of metal sulfate from the solution was made by its precipitation in sulfuric acid solutions of 40%-45% H_2SO_4.
9. . A process according to claim 8, wherein a high concentration of sulfuric acid is achieved by saturation of the solution with gas SO_3 at room temperature.

10. A process according to claim 9, wherein purification of sulfuric acid from the admixtures aimed at production of the acid ready for sale was performed by saturation with gas SO_3 up to a concentration of sulfuric acid of 98.3%.

11. A process according to claim 1, wherein said metal is iron.


H_2SO_4
Sulfide waste
Mixing
Sulfatization
H_2O
$SO_2 + SO_3$ gas
Leaching ($C_{free\ acid} \approx 5\%$)
Filtration 1& Washing
H_2O
Oxidation to SO_3
$Ca(OH)_2$
Mixing
Cake to building materials
Scrubbing
Precipitation I of $Fe_2(SO_4)_3$ up to 42% H_2SO_4
Filtration IV
SO_3 gas
Filtration II
98% H_2SO_4 product
S
Pure $Fe_2(SO_4)_3$ product
L
SO_3 gas
Precipitation II of impure $Fe_2(SO_4)_3$ up to 43.2% H_2SO_4
Decomposition of concentrate
SO_3 gas
Concentrate of impurities
Filtration III
S
L
Precipitation of impurities up to 98% H_2SO_4
SO_3 gas
Decomposition of $Fe_2(SO_4)_3$
Fe_2O_3 product
SO_3 gas

INTERNATIONAL SEARCH REPORT

Int ational Application No
PCT/IL 00/00513

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C22B1/06 C22B19/02 C22B15/00 C22B19/20 C22B3/08
C22B23/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C22B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
WPI Data, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	column 3, line 53 - line 63	7
Y	FR 2 463 189 A (METALLURGIE HOBOKEN) 20 February 1981 (1981-02-20) page 1, line 13 - line 28; examples 1,3	1,2,5,7
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 February 2001	13/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bombeke, M

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INTERNATIONAL SEARCH REPORT

In. ational Application No
PCT/IL 00/00513

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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